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An Analysis of the Technical Communications Practices Reported by Israeli and U.S. Aerospace Engineers and Scientists

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As part of Phase 4 of the NASA/DoD Aerospace Knowledge Diffusion Research Project, two pilot studies were conducted that investigated the technical communications practices of Israeli and U.S. aerospace engineers and scientists. Both studies had the same five objectives: first, to solicit the opinions of aerospace engineers and scientists regarding the importance of technical communications to their profession; second, to determine the use and production of technical communications by aerospace engineers and scientists; third, to seek their views about the appropriate content of an undergraduate course in technical communications; fourth, to determine aerospace engineers' and scientists' use of libraries, technical information centers, and on-line databases; and fifth, to determine the use and importance of computer and information technology to them. A self-administered questionnaire was mailed to randomly selected U.S. aerospace engineers and scientists who are working in cryogenics, adaptive walls, and magnetic suspension. A slightly modified version was sent to Israeli aerospace engineers and scientists working in the Israel Aircraft Industries, LTD. Responses of the Israeli and U.S. aerospace engineers and scientists to selected questions are presented in this paper.

Introduction

The NASA/DoD Aerospace Knowledge Diffusion Research Project is a cooperative effort that is sponsored by the NASA, Director of the Scientific and Technical Information Division (Code NTT) and the DoD, Office of the Assistant Secretary of the Air Force, Deputy for Scientific and Technical Information. The research project is a joint effort of the Indiana University, Center for Survey Research and the NASA Langley Research Center. This 4-phase project is providing descriptive and analytical data regarding the flow of scientific and technical information (STI) at the individual, organizational,

national, and international levels. Phase 4 examines the communications habits and practices of U.S. and non-U.S. aerospace engineers and scientists respectively. The project focuses on both the channels used to communicate information and the social system of the aerospace knowledge diffusion process. The results of this research will provide useful information to R&D managers, information managers, and others concerned with improving access to and utilization of aerospace STI.(1)

Aerospace engineering exhibits characteristics which make it an excellent platform for studying technical communications in the international workplace:

First, the aerospace industry is becoming more interdisciplinary in nature and more international in scope. Aerospace producers must maintain and improve the professional competency of aerospace engineers and scientists, enhance innovation and productivity, and maximize the inclusion of recent technological developments into the R&D process. Meeting these objectives at a reasonable cost depends on a variety of factors, but largely on the ability of aerospace engineers and scientists to acquire, process, and communicate technical information.

Second, the ability of aerospace engineers and scientists to identify, acquire, and utilize technical information is of paramount importance to the efficiency of the R&D process. Testimony to the central role of technical information in the R&D process is found in numerous studies. These studies show, among other things, that aerospace engineers and scientists devote more time, on the average, to the communication of technical information than to any other scientific or technical activity. A number of studies have found strong relationships between the communication of technical information and technical performance at both the individual and group levels. This knowledge leads to the conclusion that the communication of technical information is central to the success of the aerospace innovation process, in general, and the management of aerospace R&D activities, in particular.(2)

Third, the aerospace industry, in particular the commercial aviation sector, is characterized by the high degree of systemic complexity embodied in its products.(3) Consequently, a substantial element of technological and marketplace uncertainty exists in the design and development of each product. The production, transfer, and use of technical information is an important component of the strategies used by the aerospace industry to insulate itself from the adverse consequences of such uncertainty. Better understanding the technical communication process in the aerospace industry would contribute to increasing productivity, stimulating innovation, and improving and maintaining the professional competence of aerospace engineers and scientists.

Methodology

A list of approximately 50 U.S. aerospace engineers and scientists working in the fields of cryogenics, magnetic suspension, and adaptive walls served as the sample frame for the U.S. study. We sent two questionnaires to each member of the sample and asked each person to give one to a colleague. Approximately 300 aerospace engineers and scientists working at the IAI Tashan Engineering Center served as the sample frame for the Israeli study. We received 63 U.S. and 97 Israeli responses by the established cutoff

date. This article highlights selected results of Phase 4 pilot studies, with the Israeli responses presented first.

Demographic Information About the Survey Respondents

Survey respondents were asked to provide information regarding their professional duties, type of organization, years of professional work experience, whether English was their first (native) language, and their gender. These demographic findings follow in Table 1 (numbers given are percentages).

Table 1. Demographic Findings

	Israel %	U.S. %
Professional Duties		
Design/development	69	14
Admin./management	3	27
Research	1	35
Other	27	24
Organizational Affiliation		
Industry	92	24
Government	7	41
Academia	1	24
Not for profit	0	0
Other	0	11
Professional Work Experience		
0-9 years	20	8
10-19 years	44	14
20-29 years	26	34
30 or more years	10	44
Education		
Bachelor's degree or less	39	18
Postgraduate	61	82
Educational Preparation		
Engineer	87	86
Scientist	13	14
Current Duties		
Engineer	68	68
Scientist	10	10
Other	22	22
English First (native) Language	17	89
Gender		
Male	97	98
Female	3	2

A comparison of the two groups reveals that they are similar in educational preparation, current duties, and gender. The two groups differ in professional duties, organizational affiliation, years of professional work experience, and

education. We speculate that differences in organizational affiliation and professional duties may account for variations in individual responses. We further assume that national culture and customs might also be responsible for differences resulting from a comparison of the data.

Presentation of Data

Importance of Technical Communications

Using a five-point scale to measure importance, with "1" designated important and "5" unimportant, we asked survey participants to indicate the relative importance of their ability to communicate technical information effectively. Combining "1" and "2" responses, about 90% of the Israeli and 95% of the U.S. respondents indicate that the ability to communicate technical information effectively is very important. Table 2 shows the time that the respondents spend in communicating technical information.

Table 2. Median Number of Hours Spent Each Week by Israeli and U.S. Aerospace Engineers and Scientists in Communicating Technical Information

	Israel	U.S.
Communications with others	5.0 hrs/wk	10.0 hrs/wk
Working with communications from others	10.0 hrs/wk	10.0 hrs/wk
Percent of work week devoted to technical communications*	37.5	50

*based on a 40-hour work week

As professional work experience increases, so does the time the respondents spend on technical communication. Table 3 shows how the amount of time spent by respondents communicating technical information has changed in the past five years.

Table 3. Changes in the Past Five Years in the Amount of Time Spent Communicating Technical Information by Israeli and U.S. Aerospace Engineers and Scientists

	Israel %	U.S. %
Increased	56	42
Stayed the same	33	45
Decreased	11	13

As their careers advance, so too does the time they spend on technical communications. Table 4 shows the changes in the amount of time spent

communicating technical information as professional advancement has occurred.

Table 4. Changes in Amount of Time Spent Communicating Technical Information as Part of Professional Advancement by Israeli and U.S. Aerospace Engineers and Scientists

	Israel %	U.S. %
Increased	58	56
Stayed the same	30	25
Decreased	12	19

These data demonstrate that the ability to communicate technical information effectively is important to both Israeli and U.S. aerospace engineers and scientists. Both groups devote considerable time (about 38% and 50%, respectively, of a 40-hour work week) and effort to technical communications and consider it a significant component of their professional dutics. The amount of time spent working with technical communications increases as a function of years of experience. Thus, career success may depend on one's ability to communicate technical information effectively.

The Use and Production of Technical Communications

Israeli and U.S. aerospace engineers and scientists use and produce a variety of technical information products. Table 5 shows the types and amounts used by the respondents.

Table 5. Median Number of Technical Information Products Used in the Past Six Months by Israeli and U.S. Aerospace Engineers and Scientists

	Israel	U.S.
Letters	18	10
Memos	15	10
Journal articles	20	6
In-house technical reports	10	10
Abstracts	10	7
Conference/meeting papers	5	7
Drawings/specifications	10	4
Trade/promotional literature	10	4
Technical proposals	5	3
AGARD technical reports	1	2
Computer program documentation	5	2
Technical manuals	10	2
Audiovisual materials	2	5
U.S. government technical reports	5	5
Technical talks/presentations	6	8

The Israeli aerospace engineers and scientists in this study use more technical information products than do their American counterparts. Although U.S. respondents report greater use of conference/meeting papers, audiovisual materials, and technical talks/presentations, Israeli respondents use significantly more journal articles, drawings/specifications, trade/promotional literature, and technical manuals. Both groups report greater use of U.S. government technical reports than of AGARD technical reports. The industrial affiliation of the Israeli sample may account for their heavy use of production-oriented information products.

Notable differences between use and production were recorded for the two groups. The following table shows the types and amounts of technical information products produced by the respondents.

Table 6. Median Number of Technical Information Products Produced in the Past Six Months by Israeli and U.S. Aerospace Engineers and Scientists

	Israel	U.S.
Letters	20	10
Memos	13	6
Abstracts	1	1
Audiovisual materials	2	4
Conference/meeting papers	2	1
Drawings/specifications	4	0
In-house technical reports	5	1
Technical proposals	5	1
AGARD technical reports	0	0
Computer program documentation	2	0
Journal articles	0	0
Technical manuals	1	0
Technical talks/presentations	5	3
Trade/promotional literature	1	0
U.S. government technical reports	0	0

A comparison of these data indicate a marked difference in the production and use of technical information products. Both groups report using more information products than they produce; however, both report considerable use and production of letters and memos to communicate technical information. Again, the industrial affiliation of the Israeli respondents may account for their output of production-oriented information.

Israeli and U.S. aerospace engineers and scientists use various types of information in performing their work (Table 7). The Israeli respondents most frequently use basic scientific and technical information, in-house technical data, technical specifications, product and performance characteristics, and computer programs. They least frequently use patents, economic information, experimental techniques, government rules and regulations, and codes of standards and practices. On the other hand, U.S. respondents most frequently use basic scientific and technical information, in-house technical data, experimental techniques, computer programs, and technical specifications. Patents, codes of standards and practices, economic information, design procedures and methods, and government rules and regulations are the kinds of technical information least frequently used by U.S. aerospace engineers and scientists.

Table 7. Types of Information Used by Israeli and U.S. Aerospace Engineers and Scientists

	Israel %	U.S. %
Basic scientific and technical information	92	95
Experimental techniques	60	92
Codes of standards and practices	62	33
Design procedures and methods	66	46
Computer programs	79	78
Government rules and regulations	61	53
In-house technical data	91	93
Product and performance characteristics	82	68
Economic information	23	42
Technical specifications	91	73
Patents	12	22

Production of technical information varies for Israeli and U.S. aerospace engineers and scientists (Table 8). Israeli respondents most frequently produce in-house technical data, technical specifications, product and performance characteristics, basic scientific and technical information, and computer programs. They infrequently produce government rules and regulations, patents, economic information, codes of standards and practices, and experimental techniques. U.S. aerospace engineers and scientists most frequently produce in-house technical data, basic scientific and technical information, experimental techniques, computer programs, and technical specifications. They infrequently produce codes of standards and practices, government rules and regulations, economic information, patents, and design procedures and methods.

Table 8. Types of Information Produced by Israeli and U.S. Aerospace Engineers and Scientists

	Israel %	U.S. %
Basic scientific and technical information	53	79
Experimental techniques	37	79
Codes of standards and practices	23	7
Design procedures and methods	50	32
Computer programs	51	56
Government rules and regulations	3	9
In-house technical data	86	88
Product and performance characteristics	60	43
Economic information	14	20
Technical specifications	69	55
Patents	9	25

The aerospace engineers and scientists in this study use a variety of information sources when solving technical problems. Table 9 contains the information sources used by Israeli and U.S. aerospace engineers and scientists in solving technical problems.

Table 9. Information Sources Used by Israeli and U.S. Aerospace Engineers and Scientists to Solve Technical Problems

	Israel %	U.S. %
Informal discussions with colleagues	98	100
Discussions with experts in your organization	94	100
Textbooks	94	92
Handbooks and standards	94	64
In-house technical reports	93	92
Professional journals	88	90
Discussions with supervisors	85	66
Conference/meeting papers	77	94
Personal store of technical information	76	95
Librarians/technical information specialists	71	86
U.S. Government technical reports	67	90
Discussions with experts outside your organization	58	86
Technical information sources, such as on-line data bases, indexing and abstracting guides, CD-ROM and current awareness tools	45	37

With few exceptions, the Israeli and U.S. aerospace engineers and scientists use, in decreasing order of frequency, the same sources that Schuchman (4) reported engineers in general use in solving technical problems. Both groups begin the process of finding a solution with what Allen (5) calls an "informal interpersonal search for information." Having utilized these sources, both groups of aerospace engineers and scientists turn to the formal literature and the assistance of librarians/technical information specialists and bibliographic tools for assistance.

The Israeli respondents appear to rely on formal printed sources and internal information sources. In addition to relying more on personal stores of technical information, U.S. respondents prefer a greater mix of informal and formal information sources, specifically, more use of experts outside of the organization, librarians/technical information specialists, and U.S. government technical reports.

Content for an Undergraduate Course in Technical Communications

Approximately 33% of the Israeli respondents and 60% of the U.S. respondents indicated that they had taken a course(s) in technical communications/writing.

Approximately 87% of the Israelis had taken a course(s) as undergraduates, approximately 20% had taken a course(s) after graduation, and 40% had taken a course(s) both as undergraduates and after graduation. Approximately 26% of the Americans had taken a course(s) as undergraduates, approximately 26% had taken a course(s) after graduation, and 8% had taken a course(s) both as undergraduates and after graduation. Approximately 70% of the

Israeli respondents who had taken a course(s) in technical communications/ writing indicated that doing so had helped them to communicate technical information. Almost 94% of the U.S. respondents who had taken a course(s) in technical communications/writing indicated that doing so had helped them to communicate technical information.

Survey participants were also asked their opinions regarding aerospace majors' need for an undergraduate course in technical communications. Table 10 presents their responses to this question.

Table 10. Opinions Favoring an Undergraduate Course in Technical Communications for Aerospace Majors*

	Israel %	U.S. %
Should be taken	73	84
Taken for credit	53	84
Taken as non-credit	28	17
Taken as a required course	71	90
Taken as an elective course	36	22
Taken as part of an engineering course	64	60
Taken as a separate course	45	57
Taken as part of another course	23	13

*Percentages do not total 100.

Both Israeli and U.S. respondents indicate that aerospace engineering and science majors should take an undergraduate course in technical communications. They differ, however, on whether the course should be taken for credit. Both groups prefer a required course over an elective course. Israeli respondents prefer the course be offered as part of an engineering course; U.S. respondents are split, about half preferring a separate course and half favoring the instruction as part of an engineering course.

Israeli and U.S. respondents were asked to identify appropriate principles to be taught in an undergraduate technical communications course for aerospace majors. Their responses appear in Figure 1.

Despite reported demographic differences, Israeli and U.S. participants made similar recommendations. More than 80% of both groups stressed organizing information, defining the communication's purpose, developing paragraphs, assessing readers' needs, and editing and revising, those holistic concerns which often determine the effectiveness of a technical communication project.

Israeli and U.S. respondents also chose from a list of eight topics appropriate mechanics to be covered in an undergraduate technical communications course for aerospace majors. Their recommendations for inclusion appear in Figure 2.

Israeli and U.S. respondents demonstrate agreement in matters of interpretation and correctness. About 70% of both groups want the course to cover references, symbols, and abbreviations. The Israelis emphasize use of symbols and abbreviations, but U.S. respondents emphasize use of punctuation,

numbers, and capitalization. About 60% of both groups consider spelling important. Both groups appear to be concerned with correct and concise presentation of information.

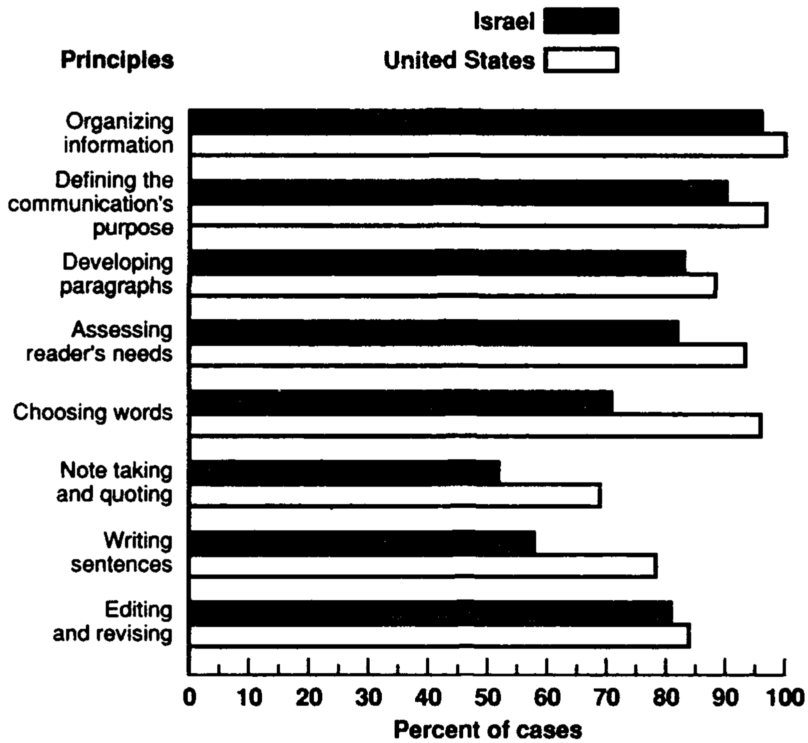

Figure 1. Recommended Principles for an Undergraduate Technical Communications Course for Aerospace Majors

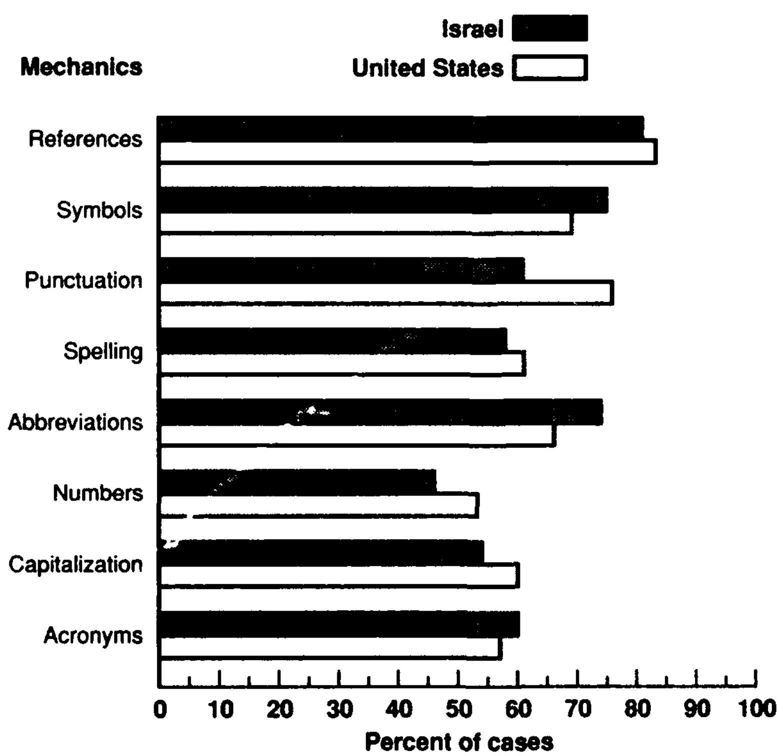

Figure 2. Recommended Mechanics for an Undergraduate Technical Communication Course for Aerospace Majors

Given a list of 13 topics, the Israeli and U.S. respondents were asked to identify appropriate on-the-job communications to be included in an undergraduate technical communications course for aerospace majors. Their recommendations appear in Figure 3.

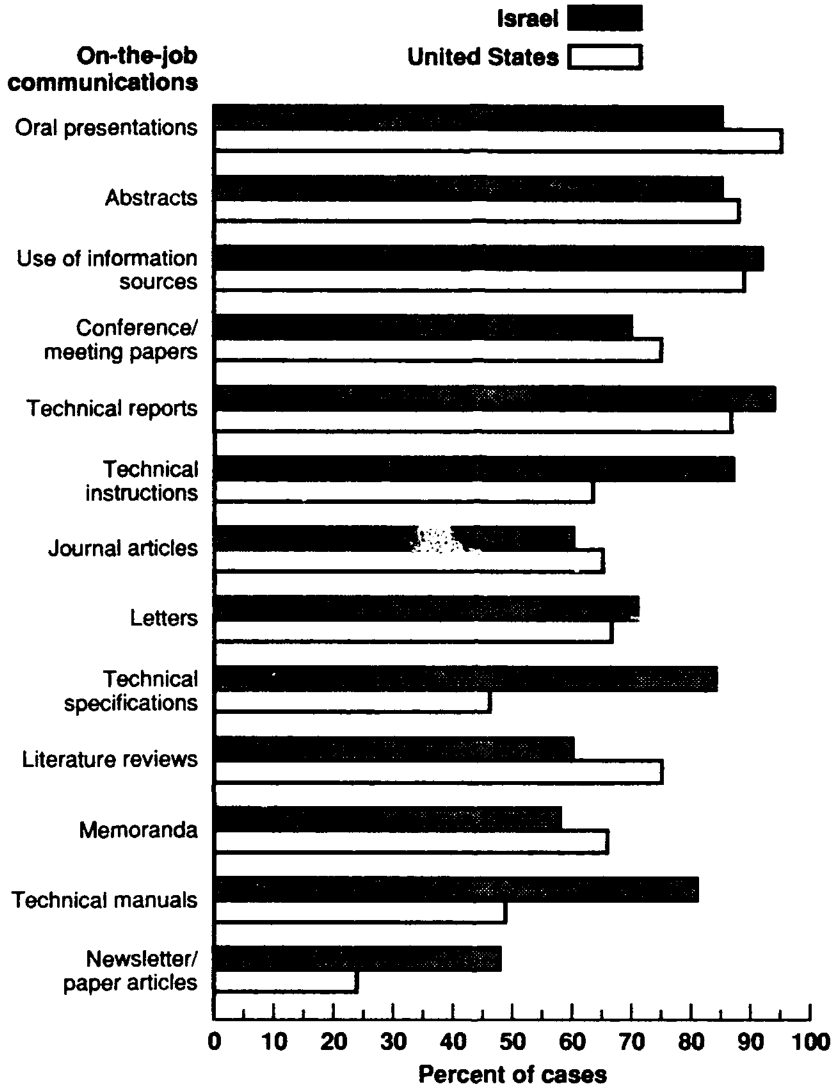

Figure 3. Recommended On-the-Job Communications to be Taught in an Undergraduate Technical Communication Course for Aerospace Majors

In an attempt to validate these findings, the top five recommended on-the-job communications were compared with the top five (on the average) technical communications products "produced" and "used" by Israeli and U.S. aerospace engineers and scientists (Table 11). Overall, the respondents' recommendations seem consistent with the types of communications they use and produce.

Table 11. Comparison of the Top Five "Produced," "Used," and "Recommended" Communication Products

Israel	U.S.
Used	
Journal articles	Letters
Letters	Memos
Memos	In-house technical reports
In-house technical reports	Technical talks/presentations
*Abstracts	*Abstracts
*Trade/promotional literature	*Journal articles
*Drawings/specifications	
*Technical manuals	
Produced	
Letters	Letters
Memos	Memos
In-house technical reports	Conference/meeting papers
Technical talks/presentations	Technical talks/presentations
Technical proposals	A/V materials
Recommended	
Technical reports	Oral presentations
Use of information sources	Use of information sources
Technical instructions	Abstracts
Abstracts	Technical reports
Oral presentations	Literature reviews

*tie

Use and Importance of Computer and Information Technology

Approximately 97% of the Israeli respondents and 93% of the U.S. respondents use computer and information technology for preparing technical communications. Of that number, approximately 95% of the Israeli respondents and approximately 98% of the U.S. respondents indicated that computer and information technology had increased their ability to communicate technical information.

Aerospace engineers and scientists use a variety of software for preparing written technical communications. For the Israeli respondents, the percentage of "yes, I use it" responses ranged from a high of 95% for word processing software to a low of 14% for desktop publishing. For the U.S. respondents, the percentage of "yes I use it" responses ranged from a high of 95% for word processing software to a low of 13% for outlines and prompters.

Israeli and U.S. aerospace engineers and scientists use a variety of computer and information technologies to communicate technical information (Table 12). The percentages of "I already use it" responses range from a high

of 84% for the Israelis and 97% for the Americans (FAX or TELEX) to a low of 2% for the Israelis (video conferencing) and 5% for the Americans (laser disc/video disc/CD-ROM). A list, in descending order, follows of the information technologies most frequently used. (Numbers are given in percentages.)

Table 12. Use, Nonuse, and Potential Use of Information Technologies by Israeli and U.S. Aerospace Engineers and Scientists

	I already use it		I don't use it, but may in the future		I don't use it, and doubt if I will	
	Israel %	**U.S.**	**Israel** %	**U.S.**	**Israel** %	**U.S.**
Audio tapes and cassettes	13	24	38	37	50	40
Motion picture film	18	30	25	23	57	47
Video tape	34	57	37	34	29	9
Desk top/electronic publishing	15	32	55	52	30	17
Computer cassette/cartridge tapes	33	32	33	35	33	33
Electronic mail	13	54	60	30	26	16
Electronic bulletin boards	13	16	48	54	39	30
Fax or Telex	84	97	12	2	4	2
Electronic data bases	49	39	44	53	7	9
Video conferencing	2	22	48	60	50	17
Teleconferencing	26	54	27	39	46	7
Micrographics and microforms	47	22	26	43	26	36
Laser disc/video disc/CD-ROM	5	5	71	75	25	20
Electronic networks	17	38	57	44	26	18

Israeli

Fax or Telex	84%
Electronic databases	49
Micrographics and microforms	47
Video tape	34
Computer cassette/ cartridge tapes	33

U.S.

Fax or Telex	97%
Video tape	57
Teleconferencing	54
Electronic mail	54
Electronic databases	39

Israeli and U.S. aerospace engineers and scientists were asked to indicate which of those information technologies not currently being used they might use in the future. The list of "I don't use it but may in the future" information technologies follows, in descending order of use. (Numbers are given in percentages.)

Israeli

Laser disc/video disc/CD-ROM	71%
Electronic mail	60
Electronic networks	57
Desk top/electronic publishing	55
Video conferencing	48
Electronic bulletin boards	48

U.S.

Laser disc/video disc/CD-ROM	75%
Video conferencing	60
Electronic bulletin boards	54
Electronic databases	53
Desk top/electronic publishing	52

Discussion

Given the limited purposes of the pilot studies, the overall response rates, and the research designs, no claims are made regarding the extent to which the attributes of the respondents in the studies accurately reflect the attributes of Israeli and U.S. aerospace engineers and scientists in general. A much more rigorous research design and methodology would be needed before such claims could be made. Nevertheless, the findings of the studies do permit the formulation of the following general statements regarding the

technical communications practices of the Israeli and U.S. aerospace engineers and scientists involved in the two pilot studies:

1. The ability to communicate technical information effectively is very important to Israeli and U.S. aerospace engineers and scientists.

2. The Israeli and U.S. aerospace engineers and scientists in these studies spend approximately 38% and 50%, respectively, of a 40-hour work week producing and working with technical communications.

3. As the Israeli and U.S. aerospace engineers and scientists in these studies advance professionally, so too does the amount of time they spend communicating technical information.

4. The Israeli and U.S. aerospace engineers and scientists in these studies make considerable use of personal knowledge and informal discussions with colleagues in solving technical problems. However, the Israeli respondents make greater use of the formal literature and internal information sources whereas the U.S. respondents prefer a mix of formal and informal sources.

5. Approximately 33% of the Israeli and 60% of U.S. aerospace engineers and scientists in these studies had taken a course(s) in technical communications/writing; approximately 70% of the Israelis and 94% of the Americans indicated that such a course(s) had helped them communicate technical information.

6. Although the percentages vary for each item, there was considerable agreement among the Israeli and U.S. aerospace engineers and scientists in these studies regarding the principles, mechanics, and on-the-job communications to be included in an undergraduate technical communications course for aerospace engineering and science majors.

7. Approximately 97% of the Israeli and 93% of the U.S. aerospace engineers and scientists in these studies use computer and information technology to prepare technical communications, and almost all of both groups indicated that the use of this technology has increased their ability to communicate technical information.

8. Apart from Fax or Telex, considerable differences were reported in the information technologies used by the Israeli and U.S. aerospace engineers and scientists in these studies.

Despite the limitations of the pilot studies, these findings contribute to our knowledge and understanding of the technical communications practices among Israeli and U.S. aerospace engineers and scientists and raise questions for future study. These data reinforce some of the conventional wisdom about technical communications and question other widely held notions. The data support earlier findings by Schuchman (4) and Allen (5) and provide an updated look at the impact of computer and information technology on technical communications in aerospace. The findings hold significant implications for technical communicators, information managers, research and development managers, and curriculum developers, and raise questions in the following areas.

If technical communications consumes approximately 38% and 50% of a 40-hour work week for Israeli and U.S. aerospace engineers and scientists, respectively, and plays a significant role in professional advancement, to what extent to aerospace engineers and scientists receive technical communications training as part of their academic preparation?

Israeli and U.S. engineers and scientists alike suggested the inclusion of oral presentation skills (85% and 95%), use of information sources (92% and 89%), and preparing abstracts (85% and 88%) in an undergraduate course in technical communications for aerospace majors. Are these on-the-job communications needs stressed in the technical communications courses available to undergraduate aerospace engineering and science majors?

Concluding Remarks

Worldwide, the aerospace industry is experiencing significant changes whose implications may not be well understood. Increasing cooperation and collaboration among nations will result in a more international manufacturing environment, altering the current structures of the aerospace industries. International alliances will result in a more rapid diffusion of technology, increasing pressure on aerospace organizations to push forward with new technological developments and to take steps designed to maximize their inclusion in the research and development (R&D) process. Aerospace producers must take the steps necessary to improve and maintain the professional competency of aerospace engineers and scientists and to enhance innovation and productivity as well as maximize the inclusion of recent technological developments in the R&D process. Meeting these objectives at a reasonable cost depends significantly on the ability of aerospace engineers and scientists to acquire and process the results of aerospace R&D.

Identifying, acquiring, and using STI is of paramount importance to the efficiency of the R&D process. A number of studies have found strong relationships between the communication of STI and technical performance at both the individual (5) and group level (6). We concur with Fischer's conclusion that the "role of scientific and technical communication is thus central to the success of the innovation process, in general, and the management of R&D activities, in particular."(2) However, as Solomon and Tornatzky point out however, "While STI, its transfer and utilization, is crucial to technological innovation, linkages between [the] various sectors of the technology infrastructure are weak and/or poorly defined."(7)

In terms of empirically derived data, little is known about the diffusion of knowledge in the aerospace industry both in terms of the channels used to communicate the ideas and the information-gathering habits and practices of the members of the social system (i.e., aerospace engineers and scientists). Most of the channel studies have been concerned with the transfer of aerospace technology to nonaerospace industries. Therefore, it is likely that an understanding of the process by which STI in the aerospace industry is communicated through certain channels over time among the members of the social system would contribute to increasing productivity, stimulating innovation, and improving and maintaining the professional competence of aerospace engineers and scientists.

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